



RISK CHARACTERIZATION OF RECYCLED TIRE CRUMB ON SYNTHETIC TURF FIELDS

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The Cal Ripken Sr. Foundation is a major benefactor for Youth Development Parks in the United States and has installed many synthetic turf fields with crumb rubber infill. Recent concerns reported by the news media regarding cancer health effects from exposure to recycled tire crumb (crumb rubber) prompted the Cal Ripken Sr. Foundation to commission a study conducted by Jenkins Environmental of the chemical and physical properties of crumb rubber used on their fields.

Background

In 2010, the Cal Ripken, Sr. Foundation realized a need in urban communities for safe, clean spaces for children to play and engage with caring adult mentors during afterschool hours. Unfortunately, many of the recreational spaces in at-risk communities are littered with hazardous debris left behind by negative influences. The multipurpose, low-maintenance, synthetic surface Youth Development Parks give underserved youth in disadvantaged communities a place to play in an organized, recreational, and well-managed setting. Over the last six years, the Foundation created 61 Youth Development Parks in 18 states.

The need is high for access to safe and positive facilities, programs, and mentors who care about the well-being and success of children facing challenging circumstances. The parks and programs make a real difference by giving kids (ages 4 to 18) a healthy, positive environment to learn and grow. The Cal Ripken, Sr. Foundation's Youth Development Parks offer at-risk youth a place to play and youth-serving organizations a state-of-the-art facility to plan on-field afterschool programming such as lacrosse, baseball, soccer, and football programs.

At each of the youth development park facilities, the Cal Ripken Sr. Foundation partners with youth organizations, Parks and Recreation Departments, schools, and other program partners to accomplish the following goals:

- Keep kids healthy and safe with a place to play and learn after school and over the summer.
- Create an environment of discipline, self-respect, and success.
- Aid in the academic, athletic, and social success of youth.
- Provide underserved neighborhoods with vibrant community spaces for kids and their families.
- Build partnerships and engage mentors to help kids make smart choices through comprehensive youth programs.

In addition to turf fields, the Cal Ripken Sr., Foundation has built 13 Adaptive Fields for children with special needs, giving them an opportunity to play team sports and have fun, just like their typical peers. Today, over 250,000 children of all abilities have access to Youth Development Park fields across the country.

Building fields out of materials that are unsafe is not acceptable to the Cal Ripken Sr. Foundation. That is why the Cal Ripken Sr. Foundation commissioned a study of crumb rubber infilled fields to investigate the potential health risks from playing on crumb rubber. The goal of this study was to determine whether the crumb rubber infilled fields were safe for use and to make decisions about the continued development of new fields. To achieve this goal, crumb rubber, soil and air over crumb rubber and soil were sampled from ten percent of the existing inventory of fields constructed as of March 2016. Samples were collected between March 24th and May 10th, 2016 and were analyzed using standardized test methods for volatile organic compounds (VOC), semivolatile organic compounds (SVOC), metals and physical characteristics. The results of analysis were compared to existing regulations. Additionally, the concentration of each chemical detected was entered into a Risk Screening Level calculator to determine the cancer and non-cancer risk for the blend of chemicals found at each field.

Artificial Turf

Artificial turfs were first developed in the mid 1960's to increase the amount of playing surfaces that were available to children in areas where natural turfs were either unavailable or unsustainable to maintain. After complaints that artificial turfs were harder and caused more injuries than natural turfs, different types of infills began to be used to cushion artificial turfs (Claudio, 2008). Today, many artificial turfs are filled with crumb rubber. The crumb rubber is used to both cushion the surface of the artificial turfs, as well as to support the artificial blades of grass that are used to more closely mimic the surface of natural turfs. The artificial grass is primarily made from three components: polyethylene, polypropylene or nylon (Desso Sports Systems, 2016).

Crumb rubber is a substance made up of fine granules of waste tires or other rubber products. Crumb rubber is mainly produced by ambient, or cryogenic processes. In ambient production, the rubber is left at ambient room temperatures and sent through a series of grinding processes to produce fine granules of rubber as well as various separation processes to remove metal, fabric and other non-rubber materials that are found in tires. Cryogenic production uses the same basic methods as the ambient process; however, rather than ambient temperatures, the tires are exposed to liquid nitrogen to reduce temperatures down to -80°C. The tires then become brittle and glass like and are able to be crushed into small pieces and the metal and fabric in the tires are removed (Scrap Tire News, 2016). In addition to artificial turf infill, crumb rubber is also used in many other applications including construction, playground infill, landscaping as well as use in other rubber products.

The turf fields designed and installed for use by the Cal Ripken Sr. Foundation are third generation synthetic turf fields. The fields have longer polyethylene fibers and an infill of recycled tire crumb. The crumb rubber product used on all of the fields was procured from Genan US and is identified as Genan High Performance Infill. The fields that were investigated are consistent in design and construction with similar drainage base, fiber and crumb rubber infill.

Health Effects

Concern over the potential for cancer, and in particular, lymphoma among soccer goalies playing on artificial turf with crumb rubber infill gained national attention in press reports and triggered the need for additional study. According to the National Cancer Institute, Surveillance, Epidemiology and End Results Program (SEER), approximately 4 out of 10 (39%) of men and women will be diagnosed with cancer at some point during their lifetime. Of the total

number of cancer cases, 8.4% of men and women will be diagnosed with leukemia (3.6%), lymphoma (4.3%) or Hodgkin's lymphoma (0.5%). (Institute, 2016) The median age of diagnosis for leukemia and lymphoma is typically 66 years of age. Leukemia is more commonly diagnosed before the age of 20 (13.8% of new cases) than lymphoma (1.6%) for the same age group. The median age of diagnosis for Hodgkin's lymphoma is 39 years with 12.6% of new cases occurring before the age of 20. (National Cancer Institute, 2016)

A human health risk assessment is the process to estimate the nature and probability of adverse health effects in humans who may be exposed to chemicals in contaminated environmental media, now or in the future. One definition of acceptable risk that has been widely accepted in environmental regulation is lifetime exposure to a substance increases a person's chance of developing cancer by one chance in a million or less. This definition is adopted by the World Health Organization and the US EPA. (World Health Organization, 2001) (USGPO)

Exposure

The source material of concern is the crumb rubber embedded in the synthetic turf and the vapor above the turf. The potential routes of exposure include ingestion, contact with skin, inhalation, and hand to mouth. Ingestion, or the oral route of exposure, includes swallowing crumb rubber granules. Contact with skin, or the dermal route of exposure, includes contact with crumb rubber granules and dust that adheres to the skin. Inhalation, which may be through nasal or oral pathways, includes the inhalation of small particles and vapors. The hand-to-mouth route of exposure is considered for the transfer of particulate matter from the hands to the mouth via direct contact or through transfer to mouth guards, food, beverages, cosmetics, gum, tobacco, athletic equipment or clothes.

A hazard characterization study was prepared in 2015-2016 in which six Ripken Foundation fields in five states across the country were selected for testing crumb rubber, soil and air for a variety of chemical and physical hazards. The results were compared to current regulatory limits for individual chemicals or minerals established by the USEPA and the Consumer Products Safety Commission (CPSC). The study ruled out hazards associated with exposures to engineered nanomaterials. The study found lead, cadmium, mercury, and Bis(2-ethylhexyl) phthalate (DEHP) concentrations that are below the regulatory limits considered safe by the Consumer Product Safety Commission for children's products.

Each detected chemical was compared to a risk screening level last updated by the USEPA in November of 2016. Risk screening levels are based upon a number of factors but most importantly they incorporate a reference dose or reference concentration. The reference dose is a maximum acceptable oral dose of a toxic substance. It is a daily oral exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious effects during a lifetime. Similarly, a reference concentration is an estimate of a continuous inhalation exposure concentration to people (including sensitive subgroups) that is likely to be without risk of deleterious effects during a lifetime. Other factors include, but are not limited to, exposure duration, exposure frequency, ingestion rate, skin exposure, and age.

Risk screening levels were generated using the chemical concentrations measured in the crumb rubber for field use by a child to young adult between the ages of 4 and 18, for 1-2 hours per day, five days per week, 50 weeks per year, for 18 years. The exposure duration reflects use by youth at school or at Boy's and Girl's Clubs and recreational use. Risk screening was calculated for ingestion, dermal exposure, and inhalation pathways and the probability of developing cancer was calculated. Additive risk values were calculated using the EPA Risk Screening Level

Calculator for all chemicals with cancer causing properties and a hazard quotient was generated for all chemicals with non-cancer health endpoints. Generally, accepted risk is one in a million or fewer excess cancers in a population from exposure. A hazard quotient less than 1 is generally accepted for non-cancer endpoints.

Several chemicals were identified in the crumb rubber that were inputted into the EPA risk screening model. These included: acetone, methyl ethyl ketone, methyl isobutyl ketone, methylene chloride, methyl acetate, m,p-xylene, o-xylene, naphthalene, toluene, 1,2,4-trimethylbenzene, propene, benzo(a)anthracene, benzo(b)fluoranthene, bis(2-ethylhexyl)phthalate, chrysene, fluoranthene, phenanthrene, pyrene, benzothiazole, arsenic, chromium, lead, magnesium, manganese, tin, barium, cadmium, cobalt, copper, strontium and zinc.

Several chemicals were tentatively identified by the laboratory as being present in the crumb rubber samples. Tentatively Identified Compounds (TICs) are chemicals that are identified during analysis and can be present in any study. The true concentration of these chemicals is not known because they cannot be compared to a known response or standard in the analytical instrument's library. Many of the chemicals are considered to be decomposition products of the compounds listed above. Very little health hazard data is reported for these chemicals. The compounds with the most information are typically approved for use as food additives. The most prevalent tentatively identified compounds included: 4-(1,1,3,3-tetramethylbutyl)-phenol, 2(3H)-Benzothiazolone, n-Hexadecanoic acid, phthalimide, 1,2-dihydro-2,2,4-trimethyl quinoline, 2-phenyl- benzothiazole, other benzothiazole compounds, other phenanthrene compounds, 9,10-dimethyl anthracene, 2,3,5-trimethylphenanthrene, 2,5-dimethylphenanthrene, and 2-methylphenanthrene.

The following chemicals detected in the air samples were included in the inhalation risk assessment: acetone, ethanol, toluene, methylene chloride, methyl isobutyl ketone (MIBK), dichlorobenzene, propene, tetrahydrofuran, n-Hexane, isopropyl alcohol, m,p-xylene, styrene, naphthalene, and phenanthrene.

The cancer risk results by field for children playing on synthetic turf fields installed by the Cal Ripken Sr. Foundation at the stated utilization rates were at or below one in a million and are considered acceptable under World Health Organization and US EPA criteria. The results are consistent with the findings from other studies (Ruffino B, 2013) (Schiliro T, 2013) (Menichini E, 2011) (Pavilonis BT, 2014; Ginsberg G, 2011) (Norwegian Institute of Public Health and the Radium Hospital, 2006).

"Risk" for non-cancer effects compares the exposure to a reference level via a ratio known as the "hazard quotient." Exposures at or below the reference level (HQ=1) are not likely to be associated with adverse health effects. As exposures increase above the reference level (i.e., HQs increase above 1), the potential for adverse effects also increases. The HQ, should not be interpreted as a probability of adverse effects. (USEPA, 2016) The non-cancer hazard quotient was below 1 for adults and in some cases higher than one for children (HQ Range: 0.9 to 4.5). Zinc and cobalt were the two minerals responsible for the increase over one. Zinc and cobalt are both essential nutrients in the human body and are found naturally in the environment. Under the exposure assumptions of 1-2 hours per day, 5 days a week per year for 18 years, it is unlikely that a typical child could ingest the amount of crumb rubber in a day over a sustained period of time to get a biologically effective dose that would contribute to adverse health effects from zinc and cobalt.

This study was in progress before the Federal government announced the US EPA, Centers for Disease Control/American Toxic Substance and Disease Registry (CDC/ATSDR), and the Consumer Product Safety Commission (CPSC) multi-agency study of recycled tire crumb used on playing fields on February 12, 2016 and the presentation of the research protocol on August 5, 2016. (USEPA, CDC, ATSDR, 2016) Jenkins Environmental is confident that the study approach, laboratory results and its interpretation of the data as they pertain to the Cal Ripken Sr. Foundation fields is scientifically sound and adds to the scientific discourse on this subject. However, new information may come to light that changes the findings expressed in this assessment. In many ways, the Federal study is an expansion of the work performed by Jenkins Environmental and will be able to address exposure factors associated with sports play and use of fields that may result in modification to the exposure assumptions used herein.

This study measured the probability of cancer or non-cancer outcomes from exposure to crumb rubber on the fields installed by the Cal Ripken Sr., Foundation and made comparisons against an acceptable risk level in the population. This study concludes that the probability of cancer or non-cancer outcomes are at an acceptable risk level for recreational exposure to crumb rubber on the fields installed by the Ripken Foundation.

The results of the study are generalizable to crumb rubber infilled sports fields of similar design, material and type of construction as those studied herein and the exposure and use factors described. It is not an endorsement of a particular field type or product. The study does not include an evaluation of ecological risk.

Limitations

This report has been prepared for the exclusive use of Jenkins Environmental, Inc. and the Ripken Foundation and/or their agents. This service has been performed in accordance with generally accepted environmental practices. No other warranty, expressed or implied, is made. Our conclusions and recommendations are based, in part, upon information provided to us by others and our site observations. The completeness or accuracy of the information provided to us by others has not yet been verified, unless otherwise noted. Observations and recommendations are based upon conditions readily visible at the sites at the time of our site visits, and upon current industry standards.

By virtue of providing the services described in this report, the preparer does not assume the responsibility of the person(s) in charge of the site, or otherwise undertake responsibility for reporting to any local, state, or federal public agencies any conditions at the site that may present a potential danger to public health, safety, or the environment. It is the Client's responsibility to notify the appropriate local, state, or federal public agencies as required by law, or otherwise to disclose, in a timely manner, any information that may be necessary to prevent any danger to public health, safety, or the environment. Under this scope of services, the preparer assumes no responsibility regarding response actions initiated as a result of these findings. Response actions are the sole responsibility of the Client and should be conducted in accordance with local, state, and/or federal requirements, and should be performed by appropriately licensed personnel as warranted.

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